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CYBERSECURITY BREACHES AND CORPORATE TAX AVOIDANCE: EVIDENCE FROM U.S. FIRMS

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ABSTRACT

This study examines the relationship between cybersecurity breaches (CSBs) and corporate tax avoidance (CTA). Using a large sample of U.S. firms from 2005 to 2018, we find a positive and significant association between the occurrence of cybersecurity breaches and corporate tax avoidance in both the full sample and the propensity score matched sample. Our results are robust to the use of alternative measures of corporate tax avoidance and CSBs. In additional analyses, we find that the presence of board-level IT governance plays an important role in mitigating the impact of CSBs on tax avoidance. These results are robust to variability in the timing of CSBs using the Heckman test and in models that employ additional control variables.

KEYWORDS: Cybersecurity breaches, IT governance, Risk management, Tax avoidance.

1. INTRODUCTION

The occurrence of cybersecurity breaches (CSBs) is a key risk that firms face in the digital world and that have the potential to lead to brand damage and financial loss. The rise in CSBs has made cybersecurity a critical area for firms, markets, and regulators (Juniper Research, 2015), with estimated costs stemming from CSBs exceeding $2 trillion in 2019. The average number of reported CSBs increased by 38 per cent in 2015 compared with the number recorded in 2014, with an average financial loss of $2.7 m (PwC, 2016). The CSBs of corporations such as Equifax, Yahoo, and Target exerted severe impacts on their market price and earnings. For example, attackers gained access to multiple databases of Equifax, a credit agency that holds the financial details of almost every person in the U.S., over the period May–July 2017. It took Equifax a month to conduct a full investigation before it publicized the breach on 7 September 2017. The Equifax stock price subsequent to the breach announcement dropped from its previous day closing price of $142.72 to $123.23 and then to its lowest price of $92.98 on 15 September 2017.

This study investigates whether the occurrence of CSBs is associated with corporate tax avoidance (CTA). We are motivated to examine this association because the non-disclosure of CSBs exacerbates agency costs and information asymmetry, which can facilitate an environment in which tax planning can flourish (Desai & Dharmapala, 2006; Kim et al. 2011). Previous research shows that data breaches can signify weaknesses in internal control systems (e.g. Lawrence et al., 2018) or in governance structures (Benaroch & Chernobai, 2017). Weaknesses in internal control and/or governance could lead to poor information quality and can potentially encourage managers to participate in CTA for the purposes of reaping benefits derived from rent extraction (Bauer, 2016; Desai & Dharmapala, 2006; Kim et al., 2011).

Based on prior research (e.g. Dyreng et al., 2010; Hoi et al., 2013; Wilson, 2009), we measure the dependent variable of our study, CTA, in three ways: the accounting effective tax rate (GAAP_ETR), permanent book–tax differences (DTAX), and unrecognized tax benefits (UTB_TA). The Privacyrights database is utilized to obtain CSB data. The occurrence of CSBs (BREACH) is measured as an indicator variable showing whether a firm reported a breach during the fiscal year. Using a large sample of U.S. firms from 2005 to 2018, we find a positive association between the occurrence of CSBs and CTA for our full sample and for our propensity score matched (PSM) sample. Our results are robust to the use of three additional measures of tax avoidance – cash tax paid (CASH_ETR), tax sheltering activities (SHELTER), and the natural logarithm of unrecognized tax benefits (UTB_LOG). In addition, we show that strength in board-level IT governance (i.e. firms with an established risk committee, compliance committee, and technology committee and the employment of IT officers in the management team) reduces the propensity of the management to engage in CTA. This finding suggests that board-level IT governance plays an important role in mitigating the impact of CSBs on CTA. Further, our results are robust with respect to the timing of CSBs, the use of the Heckman test, and the use of models that employ additional control variables.

Our study contributes to the literature in several important ways. Prior research establishes that the occurrence of CSBs gives rise to a negative market reaction (Johnson et al., 2017), increases business risk (Romanosky et al. 2014), generates higher audit fees (Li et al. 2020), results in an increase in cash holdings (Boasiako & Keefe, 2020), and relates to internal control weaknesses (Lawrence et al., 2018). This study examines the relationship between the occurrence of CSBs and CTA. We extend the prior CTA research (Chang et al., 2020) by providing evidence that increased CSBs result in higher levels of CTA. Our study supplements the previous CTA research by examining the interplay between data breaches, internal control weaknesses, and tax avoidance (Rosati et al., 2022). In addition, our paper responds to the call from Hanlon and Hetzman (2010) to provide additional evidence pertaining to internal controls regarding why firms are incentivized to participate in corporate tax avoidance.

This study also extends the IT governance literature. Prior research shows that the presence of board-level IT governance mitigates CSB risk (e.g. Haislip et al. 2016; Smith et al., 2019) and reduces agency costs. These are achieved through the monitoring and oversight of IT systems designed to enhance the effectiveness and efficiency of IT systems, policies, and procedures (Fama & Jensen, 1983). In our additional analysis, we find that the existence of a risk, compliance, or technology committee or an IT executive in the top management plays an important role in moderating the association between CSBs and corporate tax avoidance.

The rest of this paper is structured as follows. Section II develops our hypotheses. Research design is presented in Section III, empirical results in Section

IV, and additional analyses in Section V. Finally, the conclusion is discussed in Section VI.

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

The research on cybersecurity breaches has grown in line with the frequency of CSB events and the increased costs associated with CSBs. The prior literature documents the substantially negative effect of cybersecurity attacks on stock markets (Goel & Shawky, 2009; Johnson et al., 2017). There are a number of contingency factors that could affect the market reaction, such as announcement texts, firm size, and industry (Wang et al., 2013a).

The market impact is the most commonly studied area with respect to the effect of CSBs. However, CSB disclosure is one of the critical determinants of risk disclosures by an SEC registrant (SEC, 2011, 2018). CSBs can subsequently have an impact on the whole financial information system (Deloitte, 2017). CSBs have broad consequences, such as increased business risk of firms (Gwebu et al., 2014), increased audit pricing (Li et al., 2020), and privacy implications for customers, suppliers, and employees. Andreou et al. (2021) argue that the issues of cybersecurity and data privacy are becoming increasingly important owing to the information fiduciary duties of firms' directors and officers.

The reputational and operational risks posed by CSBs can have long-term effects on firms. A recent study of senior operational risk specialists finds that IT obstructions from CSBs were considered to be the highest risk for firms in 2020 (https://www.risk.net/risk-management/7450731/top-10-operational-risks-for-2020). Operational disruptions decrease firms' productivity, create economic costs, and can have an adverse impact on their financial performance (Bai et al. 2015). Firms with CSBs can incur substantial financial losses and negative reputational effects. In addition to immediate costs, such as customer credit monitoring and system restoration, the indirect consequences of CSBs (e.g. lawsuits, other liabilities, and damaged customer and partner relationships) may adversely affect the subsequent sales and income (Ponemon Institute, 2020). For instance, Target Corporation reported in its 2016 annual report that the cumulative expenses for its 2013 data breach case had accrued to $292 million after paying a legal settlement of approximately $154 million, representing 10.7% of Target's 2016 net income. The potential litigation and liability payments could be higher than the immediate costs mentioned. Specifically, the settlement costs of Anthem Insurance Company were $115 million (4.4% of its 2015 net income) for its CSB (https://www.sec.gov/Archives/edgar/data/0001156039/000115603918000013/antm-20180930x10q.htm). Romanosky et al. (2014) examine the effect of the litigation risk resulting from CSBs and find that the settlement rate is very high, 50%, for CSB firms while the average federal litigation rate for CSB firms is just 4%. They also conclude that firms are more likely to be sued if consumers are financially affected by a loss resulting from a CSB or if there has been a release of customer details.

Gwebu et al. (2014) observe a substantial decrease in profitability as a result of CSBs using a longer time horizon (a one-year period). Investors expect a decline in future cash flows due to CSBs that results in a decrease in the market value (Goel & Shawky, 2009). Investors may therefore believe that a lack of data protection is related to ineffectiveness and inefficiency in firm operations that could affect a firm's capability to generate profits (Benaroch et al. 2012). Kamiya et al. (2021) investigate the impact of CSBs on firms' credit risk. They find that firms experiencing CSBs incur a lower level of credit ratings, higher cash flow volatility, and an increased likelihood of bankruptcy. Previous studies demonstrate that CSB incidents lead to a higher level of firm risk. For instance, Lawrence et al. (2018), using CSBs as one indicator of operational control risk, show that a CSB is a potential source of weaknesses or deficiencies in financial reporting, which results in a positive relationship between audit fees and CSBs. Furthermore, recent studies document that CSBs increase audit fees (Li et al., 2020; Smith et al., 2019) but do not result in a decline in audit quality (Rosati et al., 2022). He, Frost, and Pinsker (2020) find that CSBs are negatively associated with investment efficiency and affect R&D investment in the following year, which creates future investment uncertainty.

Managers are incentivized to withhold negative information and to disclose favourable information (Beyer et al., 2010). The bias against releasing bad news arises from concerns about damaged future career opportunities, an increase in the cost of capital, and the exposure of confidential information to competitors (Kothari et al. 2009). Consequently, if the disclosure of CSBs contains unfavourable information, managers are less likely to release such information. Amir et al. (2018) show a considerably negative impact on the equity value of firms withholding CSBs than on firms voluntarily reporting CSBs. If firms' management withholds and

accumulates bad news for an extended period, the company stock price will be severely overvalued and thus a bubble will arise. Xu et al. (2019) find that a delay in CSB disclosures is indicative of a weaker information environment with the consequence that the management is more likely to undertake real earnings management.

Prior studies indicate that CSBs are a signal of internal control deficiencies or weaknesses (Benaroch & Chernobai, 2017; Benaroch et al., 2012) and affect a firm's information environment (Wang et al. 2013b). Effective internal control mechanism can align managers' interests with those of shareholders. Internal control weaknesses refer to significant negative weaknesses in policies, procedures, and systems with flow-on consequences relating to the quality of financial reporting (Haislip et al. 2016). Lawrence et al. (2018) argue that operational and financial reporting are interdependent, with weaknesses in one increase risk in the other, and show that CSBs, used as a proxy for operational control risk, are positively associated to financial reporting risk. The occurrence of CSBs suggests weaknesses in internal controls, which result from a poor information environment and quality (Cheng et al. 2013) and weak governance (Larcker et al., 2007). Bauer (2016) links internal control quality to internal governance, finding that firms with control weaknesses are more likely to avoid tax; thus, poor controls and governance around CSB events can heighten agency costs and opacity, facilitating tax avoidance and rent extraction. From the disciplining view (Chang et al. 2020), ineffective internal controls lead to underreported CBS breaches and increased tax avoidance.

From agency costs and information asymmetry perspectives, CSBs-related obfuscation can facilitate tax avoidance in a low-transparency and high-uncertainty environment (Desai & Dharmapala, 2006). Gallemore and Labro (2015) poorer financial reporting quality is positively associated with tax avoidance, suggesting that managers who withhold bad news are more likely to engage in tax avoidance. Kim et al. (2011) argue that tax avoidance encourages managerial rent extraction by allowing negative CSB information to accumulate over time. Balakrishnan et al. (2019) show that information uncertainty, asymmetry, and low earnings quality are linked to CTA, suggesting that agency costs can drive opportunistic managers to overinvest in tax avoidance; because CSB events increase uncertainty and financing constraints, firms may use tax avoidance to bolster internal resources. Boasiako and Keefe (2020) find that firms with CSBs hold more cash as well as reducing their external finance and investment. He et al. (2020) show that CSBs decrease investment efficiency and affect R&D investments in the following year, creating future uncertainty. Cash saving from tax avoidance activities is an important internal resource, and firms suffering from financial distress are more likely to engage in CTA (Edwards et al. 2016).

On the basis of the aforementioned discussion, we conjecture that CSBs are related to increased tax avoidance activities. Our hypothesis is therefore stated in the following form:

H1: There is a positive relationship between CSBs and CTA.

III. RESEARCH DESIGN

III-A. Sample selection

We obtain CSB data from the Privacy Rights Clearinghouse (PRC) database over the period 2005-2018, with information on the data breach announcement date, firm name, type of data breach, and description of events that involve individuals' identity. It results in 7,387 data breaches after excluding education, government and military, medical, and non-profit organizations. We match firms to Compustat using fuzzy name matching with manual verification. The final sample includes firms in Compustat, Audit Analytics, and BoardEx from 2005–2018, yielding 113,181 firm-year observations. When excluding financial firms (54,120), utility firms (5,380), and firms with missing data for the control variables (15,203), we are left with a final sample of 38,478 firm-year observations. There are 292 breach firms (422 firm-year observations) and 6,645 non-breach firms (38,056 firm-year observations) in our sample. Panel A of Table I presents a summary of our sample selection, and Panel B reports the industry distribution of all the firms, CSB firms, and non-CSB firms.

Table 1: Sample Description

Panel A: Sample selection	
Total Compustat data from 2005 to 2018 with state relocation	113,181
Less: Financial institutions (SIC 60–69)	(54,120)
Less: Utility industries (SIC 49)	(5,380)
Less: missing data to compute control variables	(15,203)
Total	38,478

Panel B: Sample distribution by industry

	All Firms		Breach Firms		Non-Breach Firms	
SIC CODE (one digit)	Frequency	Percent	Freq.	Per.	Freq.	Per.
1	3,379	8.78	4	0.95	3,375	8.87
2	8,485	22.05	41	9.72	8,444	22.19
3	11,338	29.47	69	16.35	11,269	29.61
4	2,305	5.99	41	9.72	2,264	5.95
5	4,405	11.45	124	29.38	4,281	11.25
7	6,227	16.18	108	25.59	6,119	16.08
8	1,978	5.14	32	7.58	1,946	5.11
9	361	0.94	3	0.71	358	0.94
Total	38,478	100.00	422	100.00	38,056	100.00

Figure 1 presents the distribution of CSB firms by year, showing CSB reporting peaked between 2012 and 2014. Figure 2 shows the distribution of CSB firms by state and indicates that California records the highest number of reported CSBs with its earliest adoption of a data breach notification law in 2002. Alabama State, South Dakota, and New Mexico implemented similar laws in 2017 and 2018. Figure 3 reports the average GAAP_ETR of CSB firms by state, with California at 0.26, and Tennessee, the state with the fewest CSBs, at 0.28.

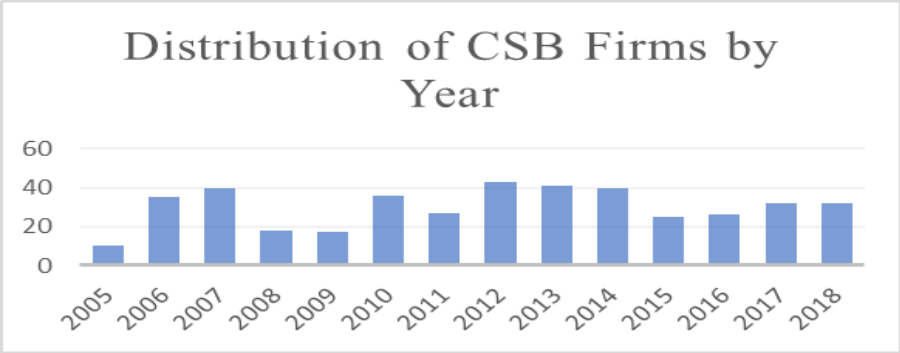

Figure 1: Distribution of CSB Firms by Year

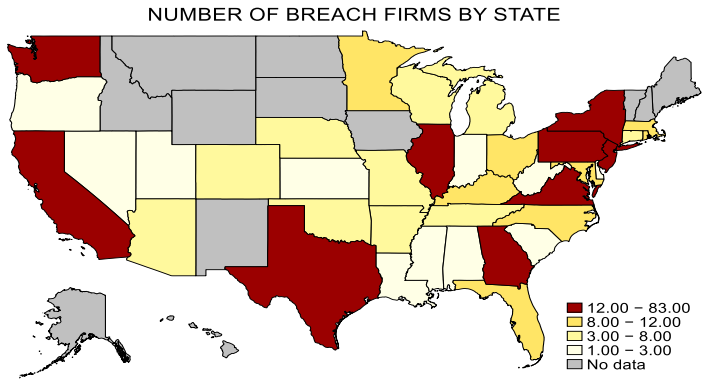

Figure 2: Distribution of CSB Firms by State

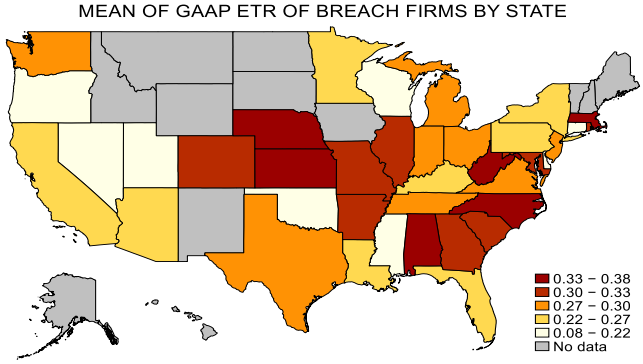

Figure 3: Mean of state GAAP_ETR for CSB firms

III-B. CTA measures

Following previous studies (e.g. Armstrong et al. 2012; Hoi et al., 2013), we measure CTA using three proxies: accounting effective tax rate (GAAP_ETR), unrecognized tax benefits (UTB_TA), and permanent book–tax difference (DTAX). GAAP_ETR is measured as total tax expense to pre-tax book income (adjusted for special items) and truncated to the range (0, 1), with lower values indicating greater tax avoidance (Dyreng et al., 2008). DTAX, based on Frank et al. (2009), captures permanent book-tax differences, where higher values reflect higher levels of tax avoidance. The specification of the DTAX model are presented in Appendix. Our last proxy, UTB_TA, unrecognized tax benefits scaled by lagged total assets, with higher values indicating greater tax uncertainty and tax avoidance.

III-C. CSBs measure

We identify CSBs using the Privacy Rights Clearinghouse (PRC) database, following prior studies (Higgs et al., 2016; Kamiya et al., 2021). We generate an indicator variable, BREACH, which equals 1 if a firm reports a CSB in year t and 0 otherwise, and conduct robustness tests by distinguishing between external and internal breaches (EXTERNAL versus INTERNAL).

III-D. Control variables

Consistent with prior literature, we include control variables related to CTA. These include firm size (SIZE) and market-to-book ratio of equity (MTB) as larger firms have more resources and commonly capitalize on the economies of scale of their tax avoidance schemes (Rego, 2003), and growth firms invest more in tax planning (Chen et al., 2010). Leverage (LEV) and cash holdings (CASH) are also controlled for since firms with a high level of leverage can benefit from the tax shield relating to debt levels (Gupta & Newberry, 1997), and firms with more cash can engage in less tax deferral (McGuire et al., 2012). The return on assets (ROA), loss carry forward (NOL), and change in loss carried forward (ΔNOL) are included in the list of control variables to capture firms' need to engage in income tax avoidance (Chen et al., 2010; McGuire et al., 2012). Foreign-sourced income (FOR_INC) is additionally controlled for because foreign operations enable income shifting across jurisdictions with different tax rates (Rego, 2003). We also control for property, plant, and equipment (CAP_INT) and research and development expenditure (R&D) since they reflect economies of scale in tax planning (Gupta & Newberry, 1997). Intangible assets (INTANG) and equity income in earnings (EQINC) capture the impact of investment activities as there are different accounting and tax rules for investments (Chen et al., 2010). We also include SALE_GROWTH in our model as growth firms invest more in tax planning activities (McGuire et al., 2012). We incorporate industry fixed effects (INDUS) and year fixed effects (YEAR) into all our regression models. Variable definitions are provided in Appendix.

III-E. Regression model

The following OLS regression model is estimated to investigate whether there is an association between the occurrence of CSBs and CTA:

$$\begin{aligned} CTA_{it} = {} & \beta_1 BREACH_{it} + \beta_2 SIZE_{it} + \beta_3 MTB_{it} + \beta_4 LEV_{it} + \beta_5 CASH_{it} + \beta_6 ROA_{it} + \beta_7 NOL_{it} + \beta_8 \Delta NOL_{it} \\ & + \beta_9 FOR\_INC_{it} + \beta_{10} CAP\_INT_{it} + \beta_{11} INTANG_{it} + \beta_{12} EQINC_{it} + \beta_{13} R\&D_{it} + \beta_{14} SALE\_GROWTH_{it} \\ & + INDUS_{DUMMIES} + YEAR_{DUMMIES} \end{aligned} \quad (1)$$

where CTA represents our proxies for corporate tax avoidance (GAAP_ETR, DTAX, and UTB_TA). BREACH is an indicator variable denoted as 1 if a firm reported that it incurred a cybersecurity breach in a given financial year. All control variables in Equation (1) are provided in Appendix. Continuous variables are winsorized at the 1st and 99th percentiles to ameliorate the risk that outliers could influence our results.

To address self-selection bias and endogeneity, we employ the propensity score matching (PSM) procedure. Following Shipman et al. (2017) and Ming & Rosenbaum (2000), we estimate the following first-stage probit model using the same controls as the baseline regression (Equation (1) and apply one-to-many matching to reduce matching bias.

$$\begin{aligned} BREACH_{it} = {} & \beta_1 SIZE_{it} + \beta_2 MTB_{it} + \beta_3 LEV_{it} + \beta_4 CASH_{it} + \beta_5 ROA_{it} + \beta_6 NOL_{it} + \beta_7 \Delta NOL_{it} + \beta_8 FOR\_INC_{it} \\ & + \beta_9 CAP\_INT_{it} + \beta_{10} INTANG_{it} + \beta_{11} EQINC_{it} + \beta_{12} R\&D_{it} + \beta_{13} SALE\_GROWTH_{it} + INDUS_{DUMMIES} \\ & + YEAR_{DUMMIES} \end{aligned} \quad (2)$$

IV. RESULTS

IV-A. Descriptive statistics

Table II provides the descriptive statistics of the variables used in Equation (1). The means (medians) of GAAP_ETR, DTAX, and UTB_TA are 0.214, 0.014, and 0.012 (0.235, 0.013, and 0.004), which are comparable to those reported in the CTA literature (Hasan et al. 2017; McGuire et al., 2012). We observe that 1.1 per cent of our sample reported CSBs in the current year. Finally, the means and medians of control variables are similar to those reported in the literature (Hasan et al., 2017; Rego, 2003).

Table II: Descriptive Statistics

	N	MEAN	S.D.	1st quartile	Median	3rd quartile
GAAP_ETR	38,478	0.214	0.182	0.006	0.235	0.350
DTAX	35,898	0.041	0.945	-0.077	0.013	0.167
UTB_TA	28,381	0.012	0.024	0.000	0.004	0.013
BREACH	38,478	0.011	0.104	0.000	0.000	0.000
SIZE	38,478	5.437	2.793	3.699	5.758	7.427
MTB	38,478	2.551	13.479	1.016	2.009	3.728
LEV	38,478	0.519	1.852	0.014	0.194	0.409
CASH	38,478	0.292	0.553	0.040	0.130	0.336
ROA	38,478	-0.552	3.614	-0.120	0.052	0.122
NOL	38,478	0.593	0.491	0.000	1.000	1.000
ΔNOL	38,478	0.332	2.251	0.000	0.000	0.027
FOR_INC	38,478	0.012	0.038	0.000	0.000	0.011
CAP_INT	38,478	0.265	0.301	0.058	0.157	0.364
INTANG	38,478	0.208	0.286	0.001	0.094	0.319
EQINC	38,478	0.001	0.003	0.000	0.000	0.000
R&D	38,478	0.092	0.256	0.000	0.000	0.070
SALE_GROWTH	38,478	0.257	1.139	-0.038	0.071	0.218

Description of variables is in Appendix.

IV-B. Pearson correlation results

In un-reported table of Pearson correlations of all the variables used in our analyses, we find that GAAP_ETR is significantly and positively correlated with BREACH ($p<0.01$), but this relationship becomes negative and significant after controlling for firm characteristics, consistent with Lawrence et al. (2018). We also find that UTB_TA is positively and significantly correlated with BREACH ($p<0.01$), supporting H1 that CSBs are positively associated with corporate tax avoidance.

IV-C. OLS regression results

Table III presents the main OLS regression results for our full sample. Column (1) of Table III provides the results for GAAP_ETR. The coefficient of our main variable of interest, BREACH, is significantly negatively associated with GAAP_ETR ($p<0.01$), implying that cybersecurity breaches are positively associated with increased levels of CTA. In terms of economic significance, a 1 standard deviation increase in BREACH is associated with a 0.29%, calculated as 0.104 (one standard deviation of the BREACH variable) *(-0.0283) (estimated coefficient in Column (1), reduction in the accounting effective tax rate (GAAP_ETR). For the control variables, the coefficients of SIZE, LEV, CASH, NOL, FOR_INC, INTANG, R&D, and SALE_GROWTH are significantly associated with GAAP_ETR ($p<0.1$ or better).

Column (2) of Table III provides the results for DTAX as a measure of CTA. The coefficient of BREACH is significantly positively associated with DTAX ($p<0.01$), suggesting that cybersecurity breaches are positively associated with higher levels of tax avoidance. Using a similar calculation method, it is shown that DTAX increases by 0.68% with a 1 standard deviation increase in BREACH. With respect to the control variables, the coefficients of SIZE, ROA, LEV, NOL, ΔNOL, FOR_INC, INTANG, R&D, and SALE_GROWTH are significantly related to DTAX ($p<0.05$ or better).

Column (3) of Table III reports the results for UTB_TA as a proxy for CTA. The coefficient of BREACH is found to be significantly positively associated with UTB_TA ($p<0.05$), indicating that cybersecurity breaches are positively associated with higher levels of corporate tax avoidance. Further, a 1 standard deviation increase in BREACH results in a 0.025%, calculated as 0.104*0.0024 increase in UTB_TA. The coefficients of SIZE, ROA, NOL, FOR_INC, CAP_INT, INTANG, and R&D are found to be significantly associated with UTB_TA ($p<0.05$ or better).

Table III: CSBS and Corporate Tax Avoidance - Full Sample

	(1)	(2)	(3)
VARIABLES	GAAP_ETR	DTAX	UTB_TA
BREACH	-0.0283***	0.0657***	0.0024**
	(-3.98)	(3.46)	(2.55)
SIZE	0.0239***	-0.0397***	0.0007***
	(37.93)	(-9.41)	(3.86)
MTB	-0.0000	-0.0002	0.0000
	(-0.53)	(-0.25)	(1.46)
LEV	-0.0016***	0.0949***	0.0000
	(-3.05)	(5.49)	(0.12)
CASH	-0.0152***	0.0354	0.0023***
	(-8.59)	(1.13)	(2.82)
ROA	0.0002	0.2025***	0.0008***
	(0.70)	(17.53)	(4.34)
NOL	-0.0370***	0.0424***	0.0029***
	(-12.53)	(3.85)	(5.59)
ΔNOL	0.0004	0.1954***	-0.0001
	(1.29)	(12.74)	(-0.62)
FOR_INC	0.0679*	0.4201***	0.0316***
	(1.83)	(3.51)	(4.15)
CAP_INT	0.0030	-0.0334	-0.0076***
	(0.51)	(-0.87)	(-7.29)
INTANG	-0.0105**	0.0819***	-0.0023**
	(-2.32)	(2.59)	(-2.06)
EQINC	-0.0395	-0.5973	0.0263
	(-0.10)	(-0.48)	(0.44)
R&D	-0.0660***	-0.2028**	0.0254***
	(-13.39)	(-2.17)	(7.47)
SALE_GROWTH	-0.0075***	0.0310***	-0.0001
	(-12.46)	(2.90)	(-0.28)
Constant	0.0992**	0.1716***	-0.0121***
	(2.57)	(4.25)	(-4.61)
Observations	38,478	35,898	28,231
Adjusted R-squared	0.287	0.245	0.100
YEAR	YES	YES	YES
INDUSTRY	YES	YES	YES

Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. All variables are defined in Appendix.

Table IV presents the main OLS regression results for our PSM sample. The coefficient estimates of BREACH remain negative and significant with GAAP_ETR (p <0.01) and positive and significant with DTAX and UTB_TA (p < 0.01 and p < 0.05, respectively). Our PSM results are consistent with the base model results provided in Table IV. Overall, the results in Tables III and IV indicate that cybersecurity breaches are positively and significantly associated with CTA, thereby supporting H1.

Table IV: CSBS and Corporate Tax Avoidance - PSM Sample

	(1)	(2)	(3)
VARIABLES	GAAP_ETR	DTAX	UTB_TA
BREACH	-0.0253***	0.0806***	0.0021**
	(-3.35)	(3.47)	(2.02)
SIZE	0.0271***	-0.0571***	0.0009***
	(29.05)	(-7.22)	(3.25)
MTB	-0.0001	-0.0020	0.0000
	(-1.50)	(-1.57)	(0.21)
LEV	-0.0003	0.0998***	-0.0002
	(-0.44)	(3.91)	(-0.54)
CASH	-0.0181***	0.0535	0.0029***
	(-6.78)	(1.01)	(2.59)
ROA	0.0002	0.2273***	0.0007**
	(0.65)	(16.59)	(2.35)
NOL	-0.0369***	0.0515***	0.0034***
	(-8.36)	(2.76)	(3.97)
ΔNOL	0.0006	0.2146***	-0.0001
	(1.44)	(9.76)	(-0.16)
FOR_INC	-0.0681	0.4279**	0.0227*
	(-1.28)	(2.37)	(1.94)

CAP_INT	-0.0046	0.0555	-0.0123***
	(-0.45)	(0.61)	(-7.15)
INTANG	-0.0025	0.1548***	-0.0027
	(-0.35)	(3.01)	(-1.57)
EQINC	0.6798	-0.7185	-0.0620
	(1.05)	(-0.34)	(-0.63)
R&D	-0.0634***	-0.2986**	0.0256***
	(-10.20)	(-2.16)	(6.32)
SALE_GROWTH	-0.0064***	0.0561**	-0.0006
	(-6.02)	(2.36)	(-1.49)
Constant	0.0695***	0.2670	0.0089***
	(3.36)	(1.58)	(3.08)
Observations	10,288	12,128	10,100
Adjusted R-squared	0.282	0.287	0.084
YEAR	YES	YES	YES
INDUSTRY	YES	YES	YES

Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. All variables are defined in Appendix.

V. ADDITIONAL ANALYSES

V-A. CSBs by breach type

Following Higgs et al. (2016) and Smith et al. (2019), we classify CSBs into EXTERNAL and INTERNAL breaches based on CSBs' type. We define EXTERNAL as equal to 1 if the type of CSB is hacking (HACK), a portable device (PORT), or stationary computer loss (STAT) and 0 otherwise. INTERNAL, on the other hand, is scored as 1 if the type of CSB is unintended disclosure not involving hacking (DISC), physical (PHYS), insider (INSD), and unknown (UNKN) and 0 otherwise.

Table V shows the results of partitioning CSBs by breach type and their relationship with corporate tax avoidance. Columns (1)–(6) report the results based on the full sample, while Columns (7)–(12) contain the results based on the PSM sample. The coefficients of EXTERNAL in Columns (1)–(3) indicate that there is a positive and significant association between the EXTERNAL type of CSBs and corporate tax avoidance (GAAP_ETR, DTAX, and UTB_TA) at p <0.01, p<0.01, and p<0.05, respectively. In addition, the coefficients of INTERNAL in Columns (4) and (5) show that the association between the INTERNAL type of CSBs and corporate tax avoidance (GAAP_ETR and DTAX) is positive and significant at p<0.01 and p<0.10. The coefficient of INTERNAL for the result of UTB_TA in Column (6) is positive but not significant. For the PSM sample, the results in Columns (7)–(12) are consistent with the findings of the full sample in Columns (1)–(6). Taken together, the results in Table V provide further support for H1 that CSBs are positively associated with CTA.

V-B. Alternative measures of CTA

To validate our results in Tables III and IV, we examine the association between CSBs and CTA using three alternative measures (CASH_ETR, SHELTER, and UTB_LOG). CASH_ETR is calculated as the cash tax paid scaled by the pre-tax accounting profit (Dyreng et al. 2010). We use Wilson (2009)'s model to measure SHELTER, which identifies firms engaging in tax sheltering. Firms in the top quintile of the estimated sheltering distribution are coded as 1, and 0 otherwise, with higher values indicating greater tax avoidance. Our third alternative measure of corporate tax avoidance, UTB_LOG, is the natural logarithm of unrecognized tax benefits at the end of the year.

The regression results for the alternative CTA measures presented in Table VI, Columns (1)–(3), are based on the complete sample, while the results of the PSM sample are presented in Columns (4)–(6). As shown in Columns (1)–(3), CSBs are significantly positively associated with all the additional measures of CTA (CASH_ETR, SHELTER, and UTB_LOG) at p<0.01. We continue to find similar results for the PSM sample in Columns (4) – (6). Generally, the results in Table VI are consistent with the main findings in Tables III and IV and support our H1 that the occurrence of CSBs is positively related to CTA.

V-C. The presence of board-level IT governance

Cybersecurity was once viewed as an IT issue, but recent research highlights its importance as a governance concern (Lawrence et al., 2018; PwC, 2016). Studies show that internal governance mechanisms, board-level expertise (e.g., technology or risk committees), and the inclusion of IT managers in senior management significantly reduce the incidence and impact of cybersecurity breaches (Haislip, Masli, et al. 2016; Higgs et al., 2016; Smith et al., 2019).

In additional analyses, we investigate whether the presence of IT governance (RISK_COMT, COMPLIANCE_COMT, TECHNOLOGY_COMT, and IT_OFFICER) helps firms to mitigate the risk of CSB occurrences. Following Smith et al. (2019), RISK_COMT, COMPLIANCE_COMT, TECHNOLOGY_COMT are indicator variables equal to 1 if the firm discloses a risk, compliance, or technology committee in its proxy statement, respectively, and 0 otherwise. IT_OFFICER is an

indicator scored 1 if the Chief Technology Officer (CTO), Chief Information Officer (CIO), Chief Security Officer (CSO), or Chief Information Security Officer (CISO) is part of the top management team and 0 otherwise.

Table VII provides the regression results of the effect of CSBs on CTA based on subsamples with strengths or weaknesses in board-level IT governance. Table VII Panel A reports the results of the subsample based on RISK_COMT with firms that have a risk committee in Columns (1)–(6) and firms that do not have a risk committee in Columns (7)–(12). In each subsample, we present the results separately for the complete sample and the PSM sample. In the presence of a RISK_COMT, the coefficient of BREACH is significantly negative in our full sample only with DTAX (Column (2)) at p<0.10. However, for all the other measures of CTA, in the presence of a risk committee, the coefficient of BREACH is non-significant. For the sub-sample of firms without a risk committee, there is a significant and positive association between CSBs and all the proxies of corporate tax avoidance at p<0.10 or better (Columns (7)–(12)).

Table V: CSBS and Corporate Tax Avoidance – Different Types of CSBS

	Full Sample						PSM Sample					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA
EXTERNAL	-0.0242***	0.0782***	0.0029**				-0.0237**	0.0919***	0.0032**			
	(-2.60)	(3.34)	(2.18)				(-2.44)	(3.50)	(2.17)			
INTERNAL				-0.0323***	0.0482*	0.0017				-0.0245**	0.0572*	0.0007
				(-3.19)	(1.76)	(1.42)				(-2.24)	(1.74)	(0.55)
Control variables	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	38,478	35,898	28,231	38,478	35,898	28,231	10,288	12,128	10,100	10,288	12,128	10,100
Adjusted R-squared	0.287	0.245	0.100	0.287	0.245	0.100	0.281	0.287	0.084	0.281	0.286	0.083
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. All variables are defined in Appendix.

Table VI: CSBS and Alternative Measures of Corporate Tax Avoidance

	Full Sample			PSM Sample		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CASH_ETR	SHELTER	UTB_LOG	CASH_ETR	SHELTER	UTB_LOG
BREACH	-0.0234***	0.3358***	0.3547***	-0.0232***	0.2935**	0.3905***
	(-2.87)	(2.59)	(4.75)	(-2.74)	(2.04)	(4.59)
Control variables	YES	YES	YES	YES	YES	YES
Observations	32,321	49,263	21,286	7,959	16,480	7,324
Adjusted R-squared	0.191		0.650	0.179		0.623
Pseudo R2		0.291			0.284	
YEAR	YES	YES	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. All variables are defined in Appendix.

Table VII Panel B reports the results of the subsamples for *COMPLIANCE_COMT*. It is evident in Columns (1)–(6) that there is not a statistically significant relationship between CSBs and CTA in firms with a compliance committee. However, Columns (7)–(12) show that CSBs are significantly and positively associated with tax avoidance in firms with no compliance committees (p<0.05 or better). The findings are consistent with those reported previously in Panel A for *RISK_COMT*. The results in Panel C for *TECHNOLOGY_COMT* show similar findings to those reported in Panel B at p<0.10 or better. Overall, our findings suggest that the existence of a risk, compliance, or technology committee plays an important role in moderating the association between CSBs and tax avoidance.

Table VII Panel D presents the effect of CSBs on corporate tax avoidance whether an *IT_OFFICER* is in the top management team or not. The results in Columns (7)–(12) are in line with the argument that IT managers have the ability to mitigate and prevent potential CSBs in the future. Firms in which an *IT_OFFICER* is not part of the top management or firms that do not have a dedicated *IT_OFFICER* are more likely to have CSBs and tend to engage in tax avoidance arrangements.

Table VII: CSBS and Corporate Tax Avoidance – Subsample Analysis for the Presence of Board-Level It Governance

Panel A: Subsample of *RISK_COMT*												
	RISK_COMT=1						**RISK_COMT=0**					
	Full sample			**PSM sample**			**Full sample**			**PSM sample**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
VARIABLES	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA
BREACH	-0.0223	-0.1321*	-0.0019	0.0061	-0.0996	-0.0010	-0.0281***	0.0706***	0.0024**	-0.0246***	0.0849***	0.0021*
	(-0.98)	(-1.74)	(-0.31)	(0.21)	(-1.08)	(-0.23)	(-3.84)	(3.63)	(2.49)	(-3.15)	(3.57)	(1.93)
CONTROLS	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	0.3589***	0.0750	0.0021	0.1667	-0.2853	-0.0089	0.0955**	0.1785***	-0.0121***	0.0667***	0.2666	0.0090***
	(9.35)	(0.34)	(0.16)	(1.15)	(-1.49)	(-0.82)	(2.45)	(4.45)	(-4.61)	(3.22)	(1.57)	(3.08)
Observations	511	552	534	169	202	218	37,967	35,346	27,697	10,119	11,926	9,882
Adjusted R-squared	0.331	0.204	0.387	0.390	0.319	0.690	0.288	0.246	0.100	0.284	0.287	0.083
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Panel B: Subsample of *COMPLIANCE_COMT*												
	COMPLIANCE_COMT =1						COMPLIANCE_COMT =0					
	Full sample			PSM sample			Full sample			PSM sample		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA
BREACH	-0.0363	0.0883	0.0012	-0.0236	0.0621	0.0020	-0.0270***	0.0627***	0.0027***	-0.0248***	0.0780***	0.0025**
	(-1.27)	(1.02)	(0.57)	(-0.88)	(0.71)	(0.70)	(-3.66)	(3.21)	(2.76)	(-3.17)	(3.26)	(2.22)
CONTROLS	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	0.1641***	0.0734	0.0009	0.2441*	0.2218	0.0066	0.0986**	0.1777***	-0.0120***	0.0671***	0.2765	0.0089***
	(2.78)	(0.34)	(0.14)	(1.91)	(1.50)	(0.55)	(2.55)	(4.33)	(-4.35)	(3.20)	(1.61)	(3.01)
Observations	835	853	790	250	318	306	37,643	35,045	27,441	10,038	11,810	9,794
Adjusted R-squared	0.180	0.159	0.314	0.189	0.368	0.412	0.290	0.246	0.100	0.284	0.288	0.082
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Panel C: Subsample of *TECHNOLOGY_COMT*												
	TECHNOLOGY_COMT =1						TECHNOLOGY_COMT =0					
	Full sample			PSM sample			Full sample			PSM sample		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA
BREACH	-0.0052	-0.0097	0.0081	0.0327	-0.1247	0.0103	-0.0270***	0.0699***	0.0020**	-0.0240***	0.0869***	0.0018*
	(-0.30)	(-0.19)	(1.33)	(1.40)	(-1.63)	(0.99)	(-3.65)	(3.53)	(2.12)	(-3.04)	(3.62)	(1.72)
CONTROLS	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Constant	0.2045***	-0.0159	-0.0020	0.1288	0.2736	0.0224	0.1022**	0.1499***	-0.0117***	0.0692***	0.2664	0.0087***
	(3.87)	(-0.11)	(-0.13)	(0.72)	(1.10)	(0.85)	(2.28)	(3.67)	(-4.11)	(3.33)	(1.57)	(3.00)
Observations	791	839	824	228	292	314	37,687	35,059	27,407	10,060	11,836	9,786
Adjusted R-squared	0.315	0.248	0.184	0.198	0.372	0.187	0.289	0.245	0.099	0.285	0.287	0.083
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Panel D: Subsample of *IT_OFFICER*												
	IT_OFFICER=1						IT_OFFICER=0					
	Full sample			PSM sample			Full sample			PSM sample		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA
BREACH	-0.0402*	0.0929	0.0035	-0.0280	0.0720	0.0039	-0.0266***	0.0633***	0.0020**	-0.0246***	0.0767***	0.0018*
	(-1.73)	(1.60)	(1.04)	(-1.10)	(0.95)	(0.81)	(-3.58)	(3.17)	(2.11)	(-3.08)	(3.18)	(1.68)
CONTROLS	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	0.0812*	0.1828	-0.0052	0.1400**	-0.0364	-0.0095	0.1034**	0.1642***	-0.0113***	0.0709***	0.2805*	0.0087***
	(1.88)	(0.96)	(-0.61)	(2.47)	(-0.22)	(-0.80)	(2.39)	(4.08)	(-3.26)	(3.40)	(1.65)	(2.97)
Observations	835	860	678	302	376	306	37,643	35,038	27,553	9,986	11,752	9,794
Adjusted R-squared	0.161	0.365	0.180	0.142	0.598	0.250	0.289	0.245	0.100	0.285	0.284	0.082
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

V-D. Timing effects of CSBs

We analyse the timing effects of CSBs on CTA by including $BREACH_{t-1}$, $BREACH_t$, and $BREACH_{t+1}$ in Equation (1). The results are presented in Table VIII, in which Columns (1)–(3) show the full sample and Columns (4)–(6) the PSM sample. Overall, it is found that CSB firms engage significantly in CTA activities one year prior to the cybersecurity breach, during the period of breach, and in the year following the breach.

Table VIII: CSBS and Corporate Tax Avoidance - Using Breach$_{T-1}$, BREACH$_T$, and BREACH$_{T+1}$

	Full sample			PSM sample		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	GAAP_ETR	DTAX	UTB_TA	GAAP_ETR	DTAX	UTB_TA
BREACH $_{t-1}$	-0.0340***	0.0880***	0.0029***	-0.0294***	0.1332***	0.0022*
	(-5.21)	(4.22)	(2.98)	(-3.20)	(3.68)	(1.71)
BREACH $_t$	-0.0219***	0.0485***	0.0019**	-0.0215***	0.0531**	0.0019*
	(-3.40)	(2.65)	(2.37)	(-2.98)	(2.40)	(1.94)
BREACH $_{t+1}$	-0.0248***	0.0427*	0.0017**	-0.0189*	0.0782**	0.0006
	(-3.43)	(1.81)	(1.99)	(-1.75)	(2.22)	(0.43)
Control variables	YES	YES	YES	YES	YES	YES
Observations	32,304	33,157	26,562	8,949	11,125	9,412
Adjusted R-squared	0.279	0.246	0.101	0.272	0.290	0.085
YEAR	YES	YES	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1 All variables are defined in Appendix.

V-E. The inverse Mills ratio (IMR) method

In addition to the use of the PSM approach, we apply the Heckman (1979) test by including the inverse Mills ratio (IMR) in Equation (1). The first-stage probit model of BREACH is estimated as in Equation (2), then the IMR variable is computed and included in Equation (1). Table IX reports the results obtained when including IMR in our main model. We find similar results to our main results in Table IV in that occurrences of CSBs are positively associated with CTA (p<0.05 or better).

Table IX: CSBS and Corporate Tax Avoidance – Heckman Analysis

	(1)	(2)	(3)
VARIABLES	GAAP_ETR	DTAX	UTB_TA
BREACH	-0.0248***	0.0971***	0.0022**
	(-3.58)	(4.41)	(2.39)
Control variables	YES	YES	YES
Observations	38,478	35,898	28,231
Adjusted R-squared	0.292	0.253	0.100
YEAR	YES	YES	YES
INDUSTRY	YES	YES	YES

Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. All variables are defined in Appendix A.

V-F. Additional control variables

As a further robustness check, we include additional control variables in our main model in Equation (1) to mitigate the potential impact of omitted variable bias. They include audit fees, the employment of a Big4 auditor, the level of auditor-provided tax service fees, selling and administrative expenses, the level of litigation risk, and technology orientation. Untabulated results show our main findings remain significant, confirming the robustness of the positive association between CSBs and CTA.

VI. CONCLUSION

Data breaches are an increasing concern for U.S. firms as they constantly face enormous pressure to cope with cybersecurity attacks and risks. While data security breaches have attracted significant media attention, they have not received a high level of attention in the accounting literature. This study examines the relationship between the occurrence of CSBs and CTA. We find a positive association between CSBs and CTA. Firms with cybersecurity data breaches are more likely to engage in CTA. Our results are robust to alternative measures of tax avoidance and CSBs, using timing effects of CSBs, the Heckman method, and models that employ additional control variables. In addition, firms are less likely to participate in tax avoidance in the presence of sound board-level IT governance. The

existence of a risk committee, a compliance committee, a technology committee, or an IT executive in the top management all play an important role in moderating the association between the occurrence of CSBs and CTA.

This study makes several important contributions. We examine the relationship between the occurrence of CSBs and corporate tax avoidance, extending prior research (e.g. Gallemore & Labro, 2015) by providing evidence that increased CSBs result in higher levels of CTA. We also contribute to the IT governance literature by demonstrating that governance mechanisms, such as the existence of a risk, compliance, or technology committee or an IT executive in the top management, play an important role in moderating the association between CSBs and CTA.

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APPENDIX: DEFINITIONS OF VARIABLES

Dependent variables	
GAAP_ETR	The GAAP effective tax rate is the total tax expense (txt) comprising both current and deferred taxes / pre-tax book income (pi) - special items (spi). *GAAP_ETR* is delimited to the [0–1] range.
DTAX	*DTAX* is the residual from Frank et al.'s (2009) model based on the year and two-digit SIC code from the regression: $PERMDIFF = \alpha_1 + \alpha_2\ INTANG + \alpha_3 UNCON + \alpha_3 MI + \alpha_4 CSTE + \alpha_5 \Delta NOL + \alpha_6 LAG\_PERMDIFF + \varepsilon$ where: *PERMDIFF* = accounting-tax difference - temporary accounting-tax difference. *LAG_PERMDIFF* = *PERMDIFF* in year t-1. *INTANG* = intangible assets. *UNCON* = equity income in earnings. *MI* = income (loss) attributable to minority interest. *CSTE* = prevailing state tax rate. Δ*NOL* = change in loss carried forward.
UTB_TA	Unrecognized tax benefits (txtubend) / lagged total assets.
Independent variable	
BREACH	Scored as 1 if a firm is subject to a cybersecurity breach in year t and 0 otherwise.
Control variables	
SIZE	Natural logarithm of total assets.
MTB	Market value of equity / book value of equity.
LEV	Long-term and current debt / total assets.
CASH	Cash and marketable securities / total assets.
ROA	Income before extraordinary items / total assets.
NOL	Scored 1 if a firm has a loss carry forward and 0 otherwise.
ΔNOL	Change in loss carried forward / total assets.
FOR_INC	Foreign income / total assets.
CAP_INT	Property, plant, and equipment / total assets.
INTANG	Total intangible assets / total assets.
EQINC	Equity income in earnings / total assets.
R&D	Research and development expenditure / total assets.
SALE_GROWTH	Change in the current year's sales / sales at t-1.
Alternative measures of corporate tax avoidance	
CASH_ETR	Cash effective tax rate, calculated as cash taxes paid (txpd) / pre-tax book income (pi) - special items (spi), truncated *CASH_ETR* to the range [0, 1].
SHELTER	Scored as 1 if a firm's estimated sheltering probability is in the top quantile in year t and 0 otherwise (Wilson, 2009). SHELTER = -4.86 + (5.20 × BTD) + (4.08 × DIS_ACC) – (0.41 × LEV) + (0.76 × SIZE) + (3.51 × ROA) + (1.72 × FOR_INCO) + (2.43 × R&D) where: *BTD* is the book–tax difference as defined by Kim (2011). *DIS_ACC* is the discretionary accruals using the modified Jones model. *FOR_INC* is the foreign income. All other variables are defined in "Control variables" above.
UTB_LOG	Natural logarithm of unrecognized tax benefits (txtubend).
Alternative measures of CSBs based on breach type	
EXTERNAL	Dummy variable scored 1 if the breach type is hacking, stationary computer loss, or portable device and 0 otherwise. https://privacyrights.org/data-breaches
INTERNAL	Dummy variable scored 1 if the breach type is insider, physical, unintended disclosure (not involving hacking, intentional breach, or physical loss), fraud involving debit and credit cards not via hacking, or unknown and 0 otherwise.
Additional variables	
RISK_COMT	Dummy variable scored 1 if the firm discloses the presence of a risk committee in its proxy statement for the current year and 0 otherwise. (BoardEx)
COMPLIANCE_COMT	Dummy variable scored 1 if a firm discloses the presence of a compliance committee in its proxy statement for the current year and 0 otherwise. (BoardEx)
TECHNOLOGY_COMT	Dummy variable scored 1 if a firm discloses the presence of a technology committee in its proxy statement for the current year and 0 otherwise. (BoardEx)
IT_OFFICER	Dummy variable scored 1 if the Chief Information Officer (CIO), Chief Technology Officer (CTO), Chief Information Security Officer (CISO), or Chief Security Officer (CSO) is on the top management team and 0 otherwise. (BoardEx)
IMR	Inverse Mills ratio from the first-stage model of Equation (2).